MICROBIAL CONTROL OF PLANT PATHOGENS

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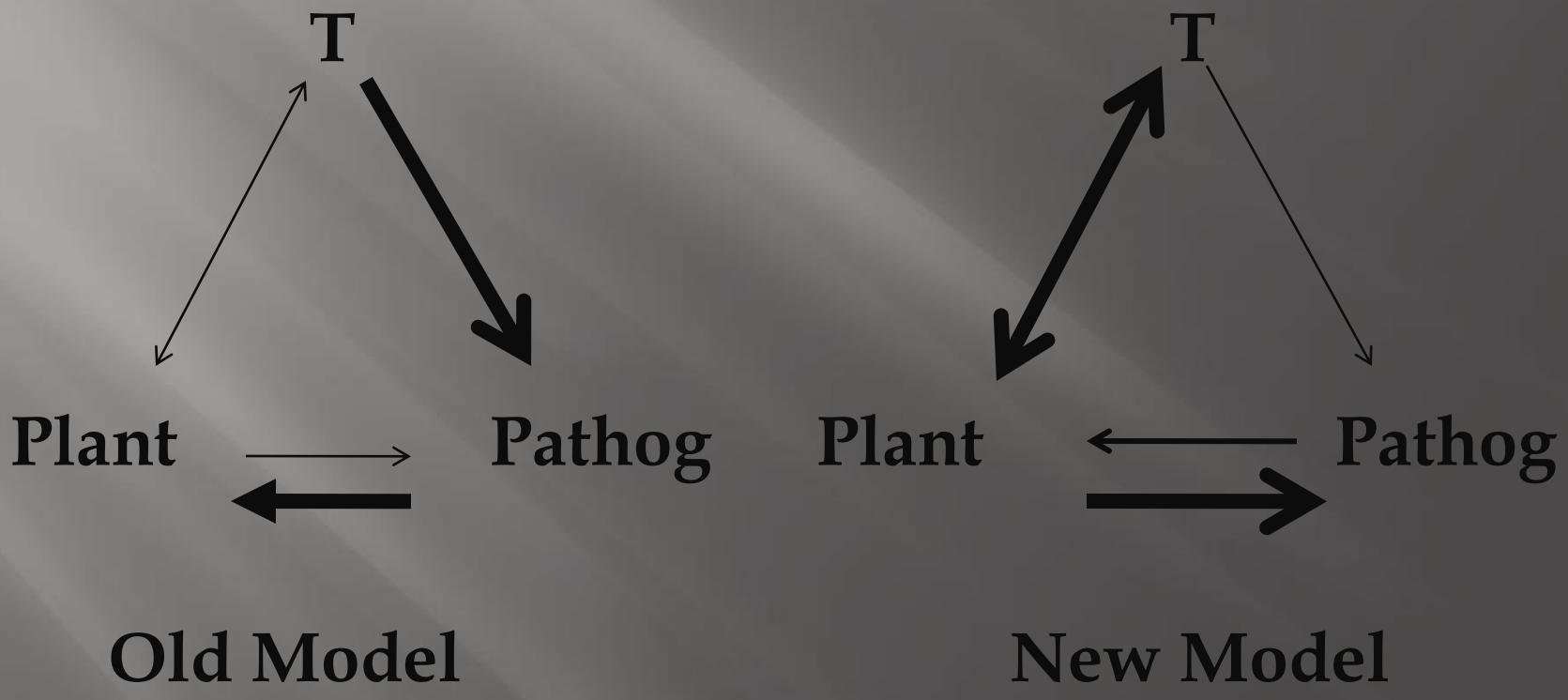
Classes & Mechanisms of Agents

- Competition
  - Atoxigenic strains of *Aspergillus flavus*
- Mycoparasite
  - Contans (*Coniothyrium minitans*, a mycoparasite of sclerotia)
- Antibiosis
  - Serenade, Cease, other *Bacillus*-based products that work primarily by activity of antibiotics; some are contact materials for foliar applications.

Classes of mechanisms

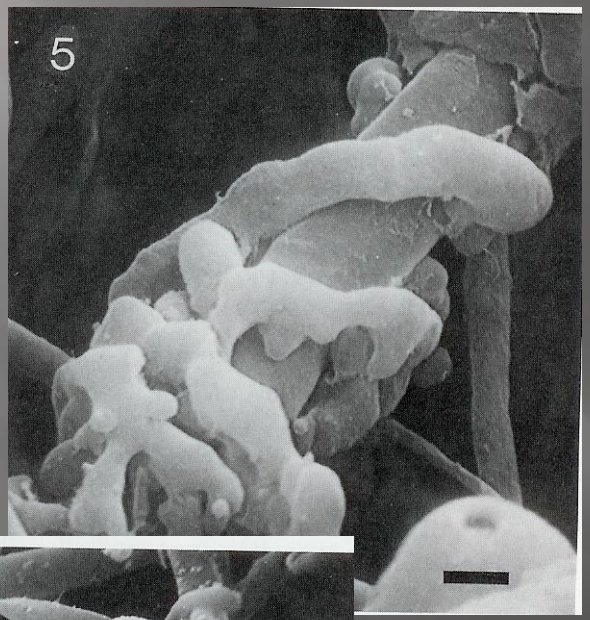
- Induced resistance
  - Plant growth promoting rhizobacteria, other mechanisms as well such as phenazine resistance.
  - Harpin
- Hormonal alterations, both + or –
- MULTIPLE MECHANISMS
  - A great many organisms, including mycorrhizal fungi, PGRP and other bacteria in a variety of uses ranging from foliar to soil to post harvest.
- This talk will discuss primarily *Trichoderma*, but similar stories could be put together with other organisms.

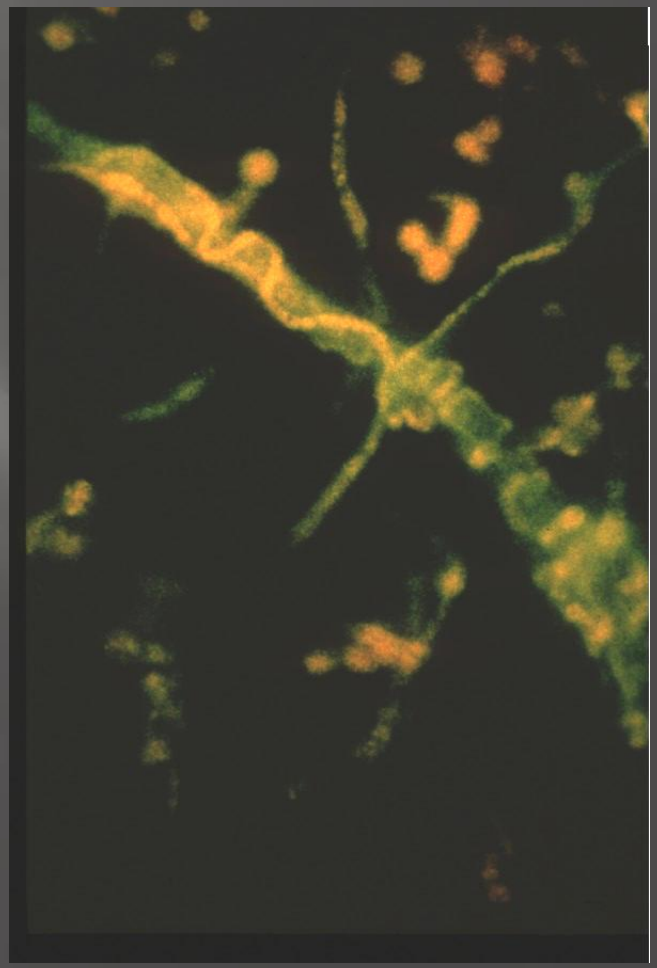
Two models of plant disease control

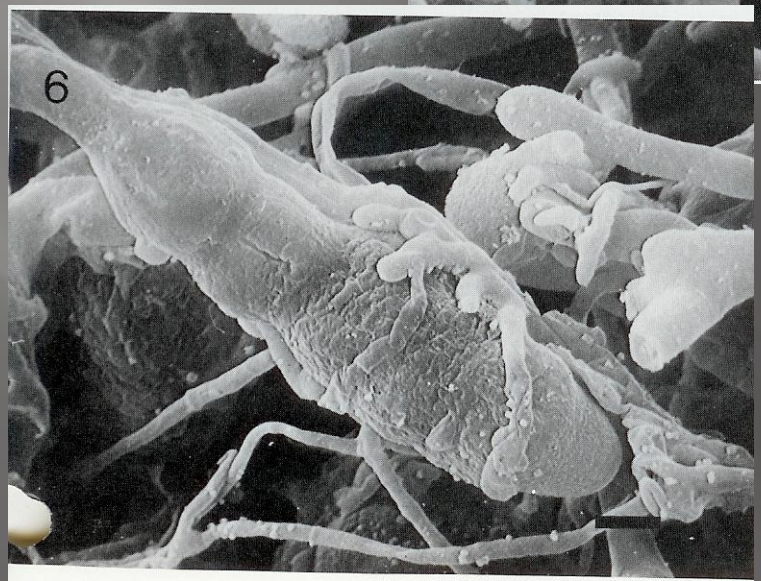


Old Model— *Trichoderma* Mycoparasitism

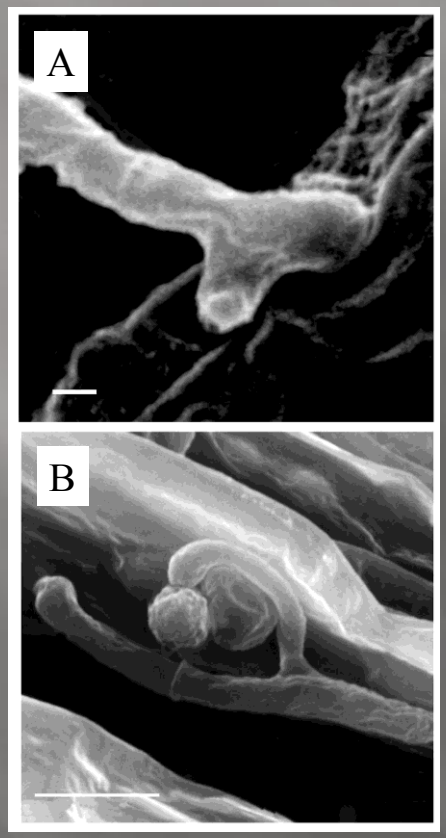
Probably is important in some systems but may be primarily of ecological importance.

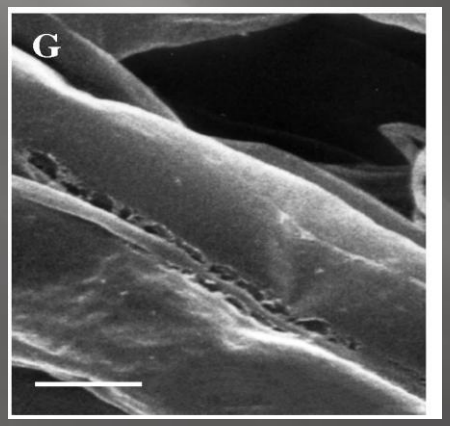






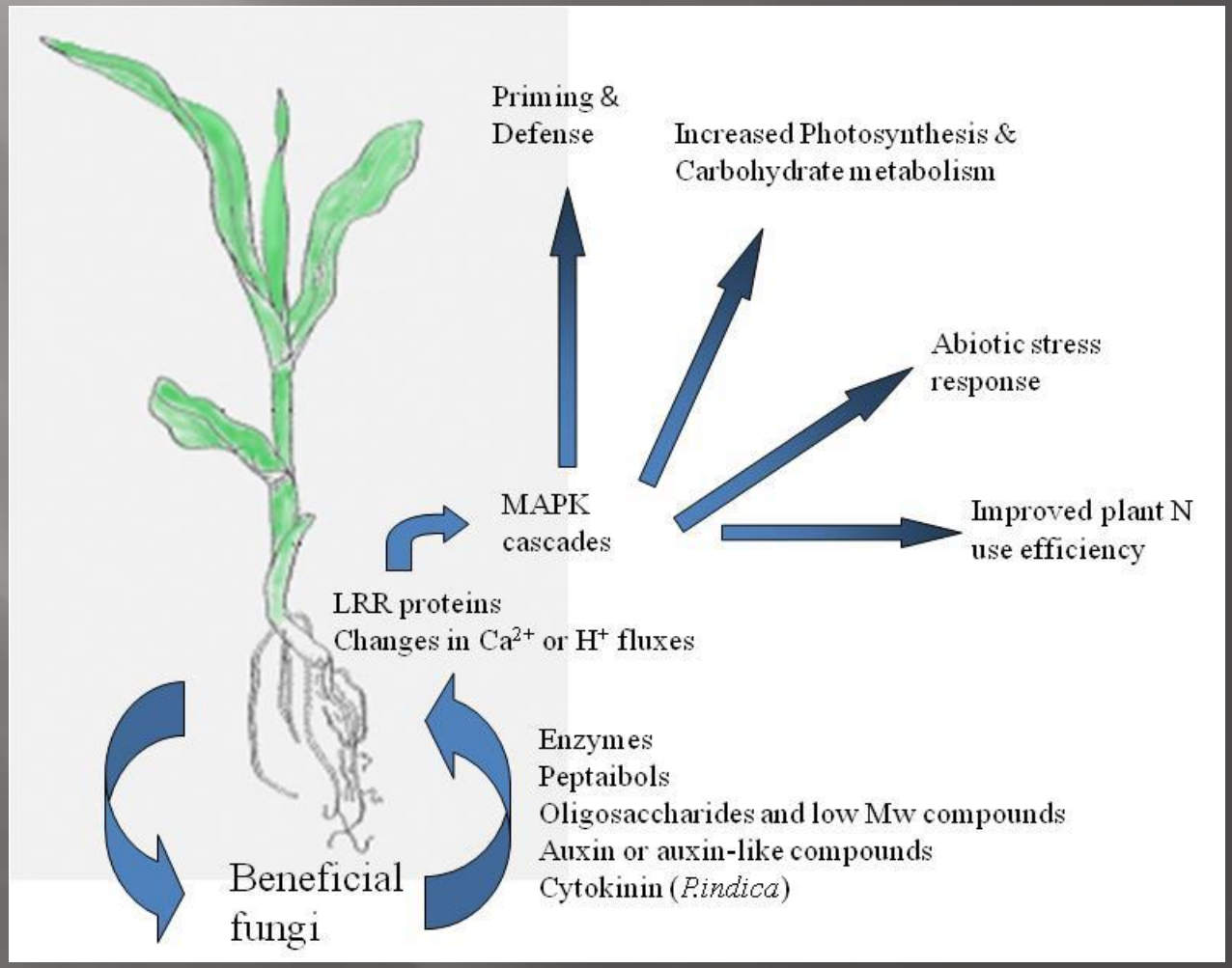
Interactions of *Trichoderma* with plant roots



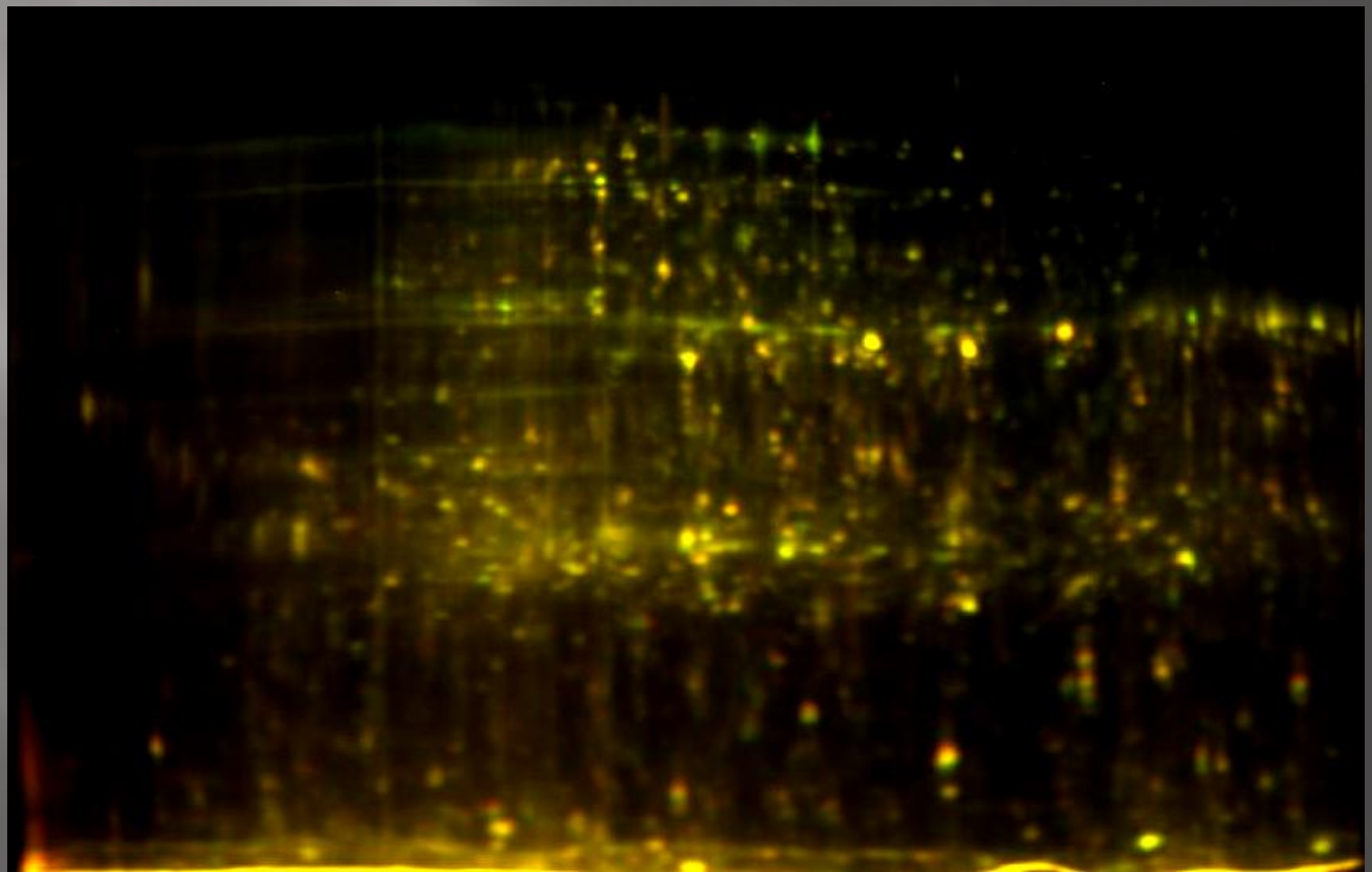


From Yedidia, I., Benhamou, N., and Chet, I. 1999. Appl. Environ. Microbiol. 65 (3):1061-1070.

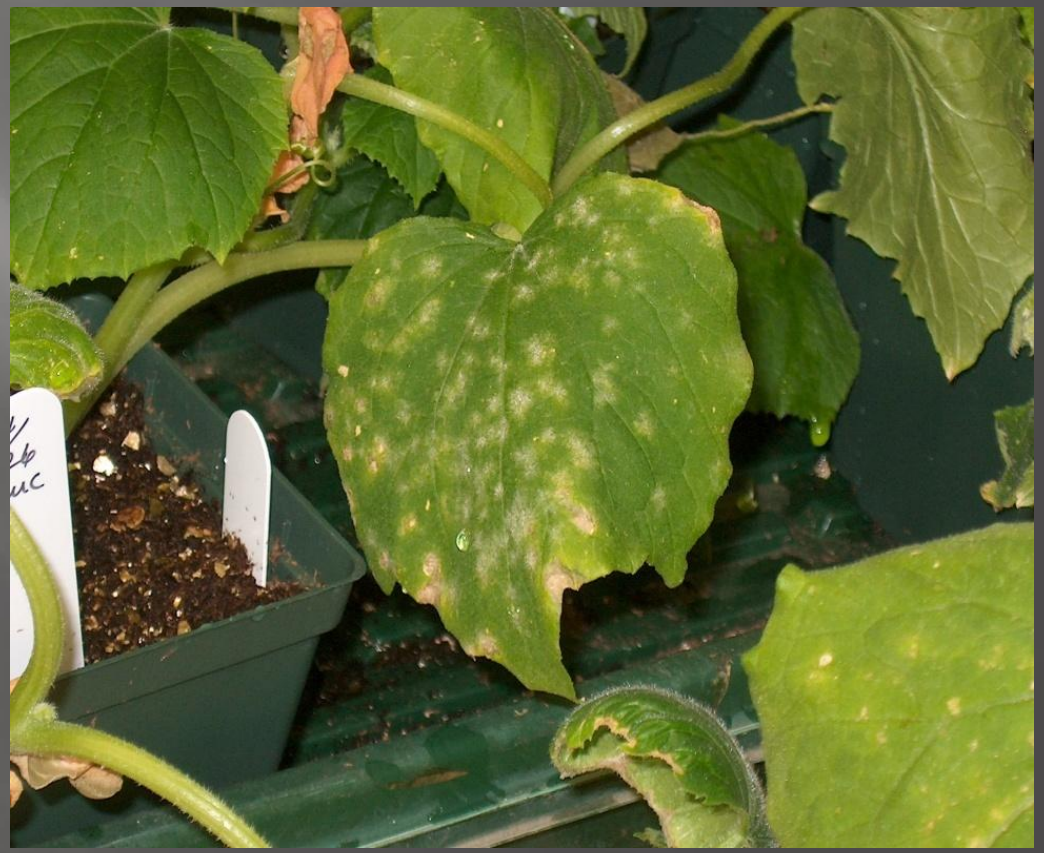
Global Effects of Endophytic *Trichoderma* strains



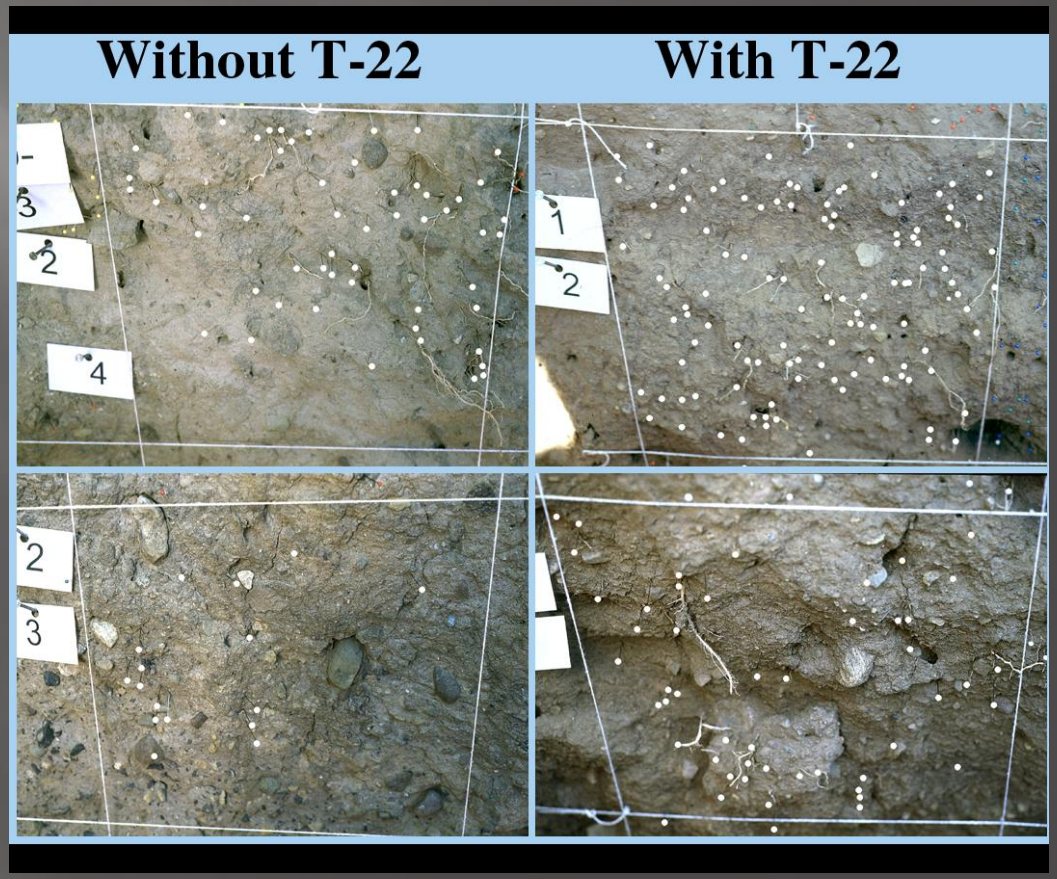
Trichoderma spp. induce systemic changes in plant protein and gene expression



Induced systemic disease resistance



That result in season-long advantages to the plant



Trichoderma spp. increase N fertilizer use (NUE efficiency—rice in Phillipines

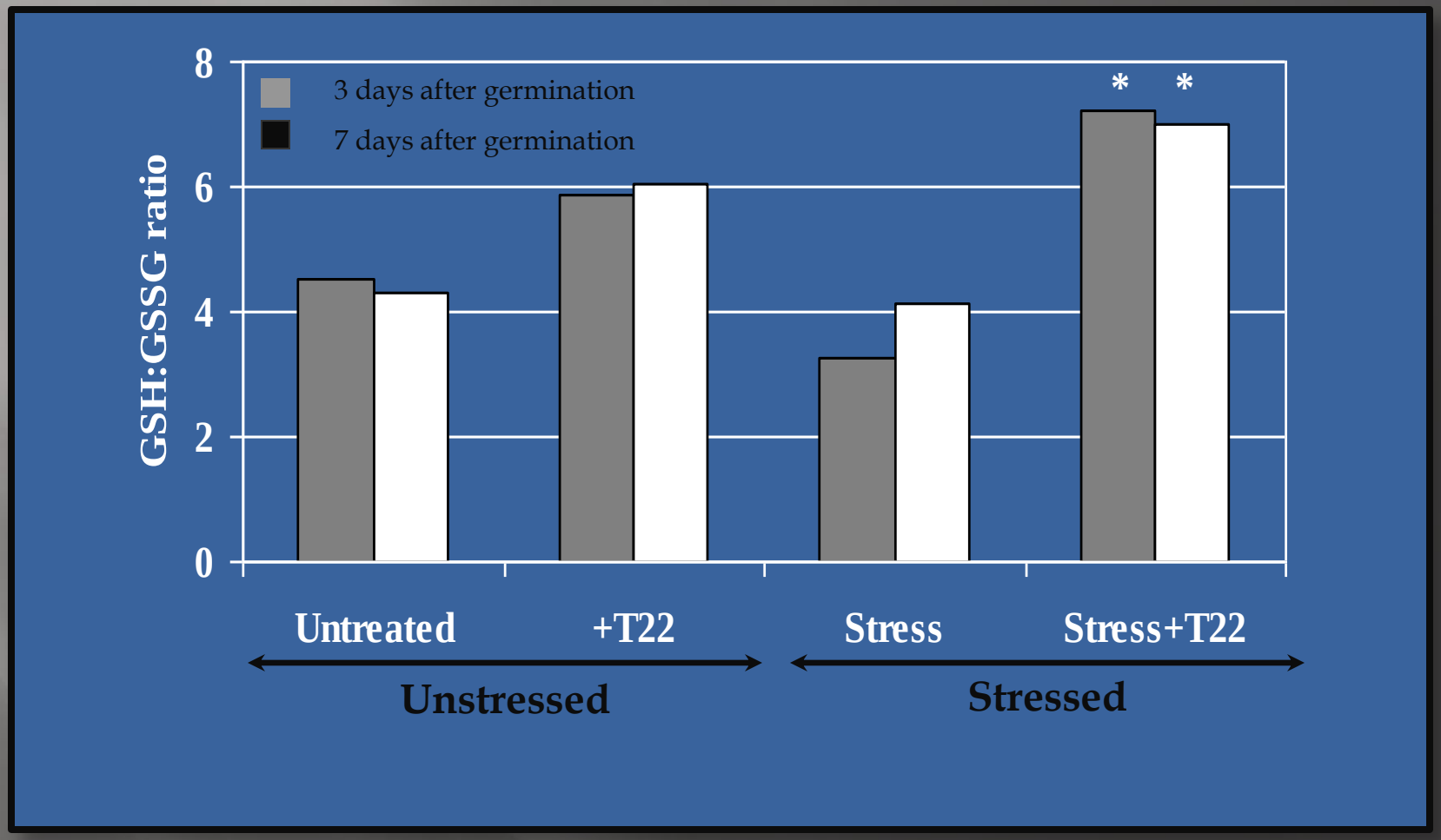
Treatment	Yield (tons/ha)	Yield (tons/ha)
No fertilizer check	5.78 C	----
	Full Rate N	Half Rate N
No Tricho.	7.29 AB	6.55 BC
ST F11	7.28 AB	7.77AB
ST xyz	7.04 AB	6.78 BC
ST RR	6.79 AB	7.55 AB
RD F11	6.79 AB	8.52A
RD xyz	7.55 AB	7.3 AB
RD RR	7.29 AB	7.05 AB

Trichoderma strains alleviate abiotic stresses

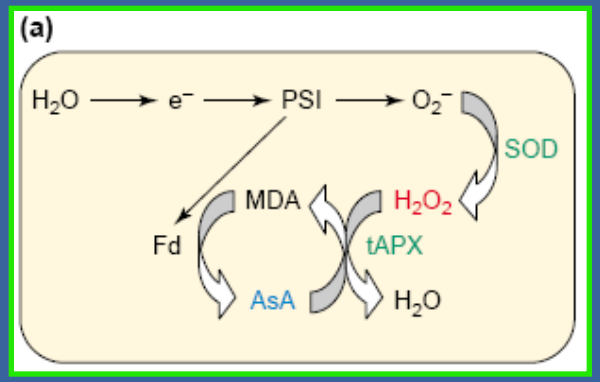
Water deficit

Salt

Mechanism: Control of ROS (Enhanced antioxidant levels)



ROS production and scavenging in plants; abiotic stresses

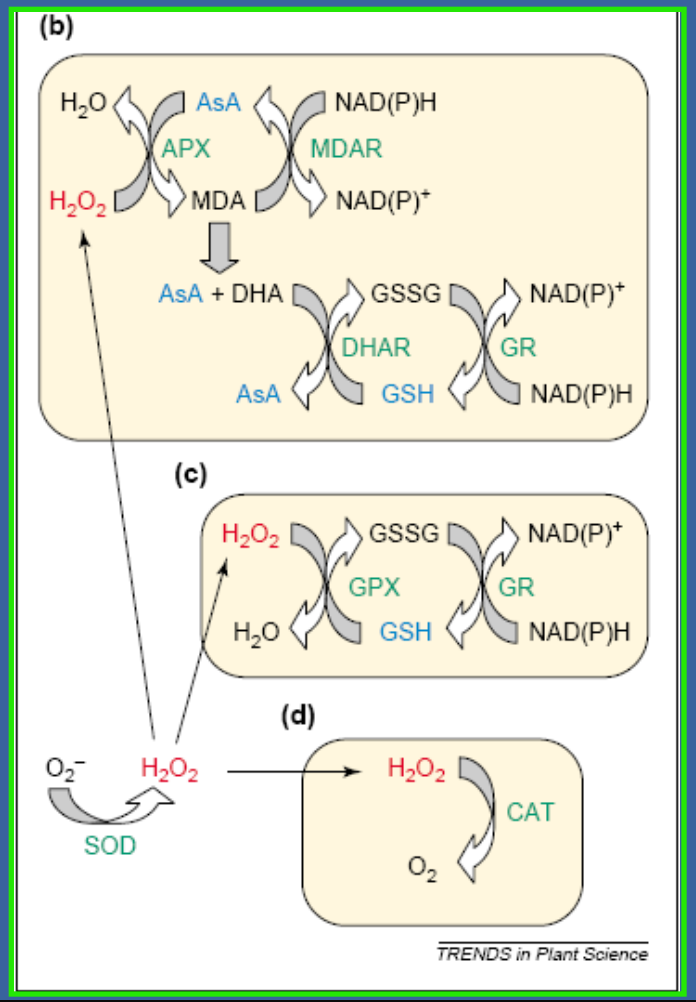


Water-water cycle

Glutathione-ascorbate cycle

GPX cycle

Catalase



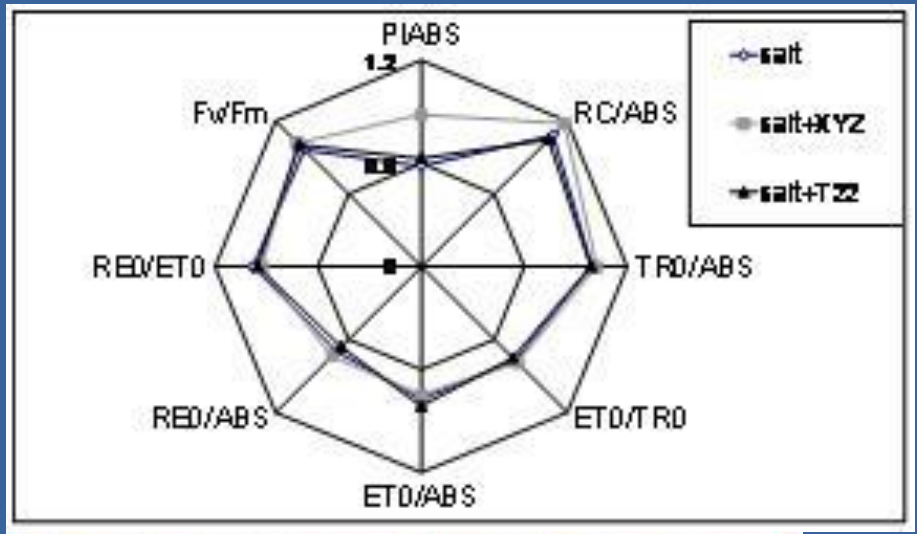
Enhanced nutrition by increasing antioxidant levels in foods?

All processes require energy

- In plants, energy is derived from photosynthesis followed by respiration.
- Proteomics demonstrate up-regulation of elements of both processes.

Components of PI_{ABS} were affected by stress and symbiosis

PIABS= performance index
RC/ABS = Ratio of chlorophyll molecules to antennae
TR0/ABS (φ_0) = Maximum yield of primary photochemistry
ET0/TR0 (ψ_0) = Efficiency (probability) by which an e^- moves from $quinone_A^-$ to plastoquinone (PQ)
ET0/ABS = e^- transport activity per absorption
RE0/ET0 = efficiency/ probabilities than an e^- moves from the reduced plastoquinone to the PSI

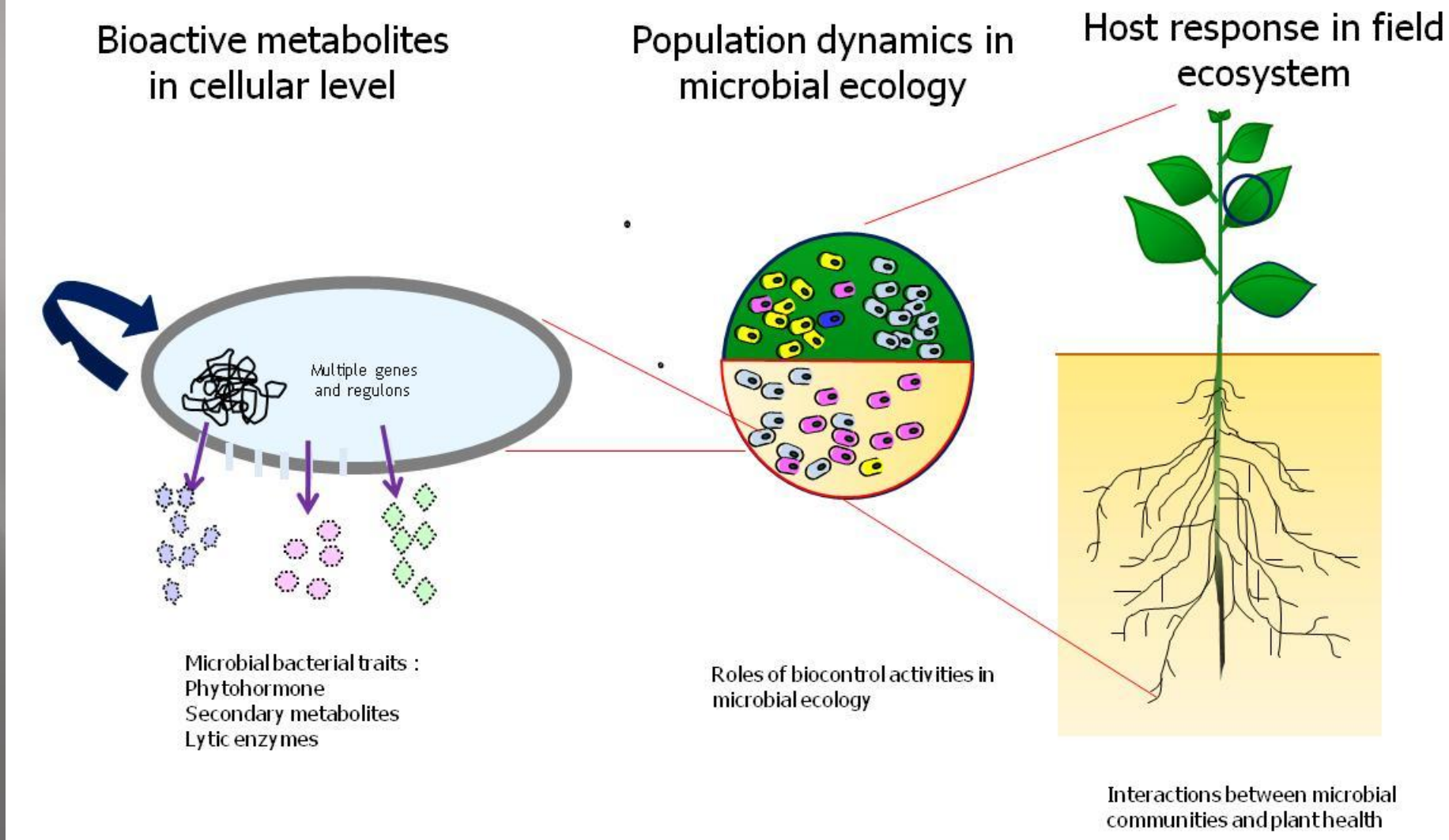


Trichoderma are multifunctional endophytic plant symbionts

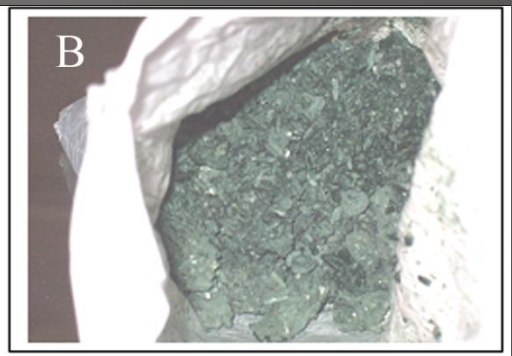
- They induce systemic resistance to diseases
- Increase nitrogen use efficiency
- Increase resistance to abiotic stresses
  - Alleviation of ROS toxicity through enhancement of redox pathways in plants.
- Increase energy production in plants
  - Enhance photosynthetic efficiency especially under plant stress.
- Revitalize seeds and enhance germination
- Enhanced nutrient level of produce

Only one property regulated by FIFRA.

Different strains give different advantages, and the most efficient of all may be consortia



International Developments—Cottage Industries



Large National and Grower Setups

10’s of thousands of hectares treated directly through irrigation water from spores or liquid fermentation contents. Funded through UNESCO in Honduras.

International systems

- Very high quality preparations and formulations are very easy to make.
- Can be produced on a cottage or very large scale. If you buy melons in the winter, you probably have purchased fruits protected and treated with the Honduran system.

Microbial consortia—which should be regulated/registered?

- A mixture of four MEPSs, no pest control claims.
- One registered biopesticide, three MEPSs for which no pest control claims are made
- A mycorrhizal preparation (MEPS)
- A MEPS registered biopesticide plus *Rhizobium*
- Composts
- A mix of five or more organisms

Challenges for registration

- MEPSs
  - Multifunctional, sellers have choices as to what claims to make, disease control may not be very important.
  - Work almost exclusively by reprogramming plant gene expression, agent frequently not present where effect takes place, or on eaten portion of plants.
  - Usually only normal plant metabolites present, nutrition may be augmented.
  - Multiple mechanisms

Challenges for regulators

- Is there a method/mechanism to regulate microbial consortia with multiple functions?
- Do organisms that act primarily or completely by altering plant gene function need to be regulated?
- If pest control is a small part of the total product package, does this make a difference?
- Does the distinction between exempt organisms or communities and nonexempt ones make any sense?

Cost and Time of Registration

- Full registration = several million dollars and 2-3 years.
- Prevents products from entering the marketplace.
- How will we deal with microbial consortia, which are going to be the norm for these MEPSs?

Publications

Harman, G.E., C.R. Howell, A. Viterbo, I. Chet, and M. Lorito. 2004. *Trichoderma* species---opportunistic, avirulent plant symbionts. Nature Rev. Microbiol. 2:43-56.

Harman, G.E., M.A. Obregón, G.J. Samuels, and M. Lorito. 2010. Changing models of biocontrol in the developing and developed world. Plant Dis. 94:928-939.

Lorito, M., S.L. Woo, G.E. Harman, and E. Monte. 2010. Translational research on *Trichoderma*: from 'omics to the field. Annu. Rev. Phytopathol. 48:395-417.

Shoresh, M., F. Mastouri, and G.E. Harman. 2010. Induced systemic resistance and plant responses to fungal biocontrol agents. Annu. Rev. Phytopathol. 48:21-43.